Aetiology and interrelationship of some common skeletal deformities

(Talipes equinovarus and calcaneovalgus, metatarsus varus, congenital dislocation of the hip, and infantile idiopathic scoliosis)

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SUMMARY The Edinburgh Register of the Newborn 1964–1968 and the Edinburgh Scoliosis Clinic 1964–1971 have been used to establish the population frequency in the city of the idiopathic forms of talipes equinovarus and calcaneovalgus, metatarsus varus, congenital dislocation of the hip, and infantile scoliosis. A survey of 165 patients now aged 7 to 11 years showed an aetiological relationship, but with differing environmental factors. These factors were established by comparison with the Edinburgh Register control group of 692 normal infants born over the same period, giving a unique opportunity to obtain more accurate antenatal data than has previously been possible. The principal associations were: talipes equinovarus with antepartum haemorrhage and maternal hypertension; metatarsus varus with twin pregnancies; congenital dislocation of the hip with first born children, older than average fathers, breech presentation, a significant lack of menstrual problems in the mother, and maternal upper respiratory infection during pregnancy; infantile idiopathic scoliosis with breech presentation, prematurity, and the onset of the curve in the winter months. No significant association with raised intrauterine pressure (hydramnios or oligohydramnios) was found among these simple idiopathic deformities. It is concluded that the multifactorial genetic background is likely to be similar in all, but that the additional environmental element is variable.

It is customary to consider these skeletal deformities as separate entities and their essential similarity is often overlooked. In each case apparently normal structures seem to be pushed out of position and then fixed, to give the familiar structural deformity. What must initially be the result of only a minor intrauterine disturbance deteriorates into a more complex deformity as secondary pathology develops with the growth of the child.

There have been many surveys relating to genetic and other factors in their aetiology (clubfoot,^{1–4} congenital dislocation of the hip,^{5–9} infantile idiopathic scoliosis^{10 11}). Current evidence indicates that the risk of recurrence in the near family is usually low at about 5%. Their pattern of inheritance is multifactorial and thus external environmental factors must also play a part. These are likely to be intrauterine, though immediate postnatal management is sometimes relevant. The nature of these

intrauterine factors remains speculative, though antenatal moulding by abnormal pressures in utero associated with hydramnios, oligohydramnios, and malposition was suggested centuries ago. Certainly the severe deformities of the 'compressed baby' in Potter's syndrome would indicate in this instance that the associated oligohydramnios was causative.

The possibility that all these deformities had some common factor in their aetiology was suggested by Browne.¹² More recently, Dunn¹³ has developed the hypothesis of compression in utero in connection with 'congenital postural deformities'. Watson¹⁴ discussed the relationship between congenital dislocation of the hip and infantile scoliosis. Some environmental factors are known: congenital dislocation of the hip has long been known to be commoner in first born children and in breech presentations, or after version late in pregnancy. There is also an unexplained excess of cases among children born in the winter months.^{5 15 16} The

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season of birth in infantile idiopathic scoliosis is unremarkable but the onset of the curve is significantly more common in the winter.¹¹ No environmental factors have been positively identified in the foot deformities, though it is common knowledge that metatarsus varus has a regional difference in frequency, being commoner in North America than Britain.

The aim of the current survey was to obtain data from the Edinburgh Register of the Newborn in which all births in the city from 1964 to 1968 were monitored, including detailed information collected from antenatal records and from the parents of all infants with a congenital defect. Over the same period, similar data were recorded for the births of nearly 700 normal children. It seemed that this was a unique opportunity to obtain more accurate antenatal data than has previously been possible for these deformities, particularly in relation to intrauterine pressure disturbances, and comparisons are made within the group and also with the normal 'control' pregnancies.

Material and methods

The Edinburgh Register of the Newborn* included 52 029 births in the city during 4½ years between 1964 and 1968. It had been set up with funds from the Distillers Company following the thalidomide disaster in order to monitor congenital defects. Information relating to the pregnancy and maternal and family history of all infants with a congenital defect was recorded both from antenatal medical records and from the mother during the neonatal period. The same detailed information was obtained from 692 births of normal children over the same period; at first every hundredth and later every fiftieth birth in the city. Domiciliary as well as institutional births were included and so it is likely that ascertainment of congenital defects is nearly complete.

It was realised that a diagnosis made at birth of 'idiopathic' club foot or congenital dislocation of the hip might have to be adjusted at a later age if it became apparent that some additional neurological disorder or other syndrome was present. The current survey was therefore delayed in order that these children could be examined (or medical records obtained) at not less than 7 years of age. That is, at the time of this survey the patients ranged from 7 to 11 years. It is felt that similar defects secondary to neurological damage or associated with known syndromes have all been excluded, and the remainder now form a homogeneous group of simple 'idiopathic' deformities.

* Unpublished. Held at the Department of Orthopaedic Surgery, University of Edinburgh.

TALIPES EQUINOVARUS (33 PATIENTS)

The register noted a total of 101 cases. Forty were immediately discarded from the survey as being clearly secondary to neurological damage such as spina bifida and meningocele. Nine cases (lethal in the neonatal period) suffered from Potter's syndrome associated with severe compression in utero and absent kidneys and were also excluded. A further 19 were subsequently excluded as chromosome anomalies, the Freeman-Sheldon syndrome, and less obvious neurological defects became apparent.

TALIPES CALCANEVALGUS AND METATARSUS VARUS (22 AND 10 PATIENTS, RESPECTIVELY)

These usually rather minor foot deformities were included, though very few were recorded in the Register. None was subsequently discarded as being associated with neurological disorder or known syndromes.

NEONATAL CONGENITAL DISLOCATION OF THE HIP (83 PATIENTS)

The total number in the Register was 236, but since 83 of them had been included in a previous genetic and epidemiological survey from the area¹⁷ and their records were exceptionally complete, only these patients were followed up for the current survey. It is unlikely that there is any significant bias in selection.

No case was subsequently discarded as having primary neurological damage or suffering from a known syndrome. Congenital dislocation of the hip developing after the neonatal period was not included.

INFANTILE IDIOPATHIC SCOLIOSIS (26 PATIENTS)

No case was noted at birth and thus none appeared in the Register. However, all patients in Edinburgh are treated at one Scoliosis Clinic and it was possible to identify children developing this deformity who were born in the city during the period under consideration. Infantile scoliosis was defined as that presenting up to the age of 3 years, and a search of the Edinburgh Scoliosis Clinic records up to 1971 identified 26 children born within the city between 1964 and 1968. Clearly there could be some inaccuracy in population frequency here, in that a child may have left the district before developing scoliosis, thus remaining unidentified.

The total of 174 deformities included only 165 subjects, since one patient had three defects and seven had two (table 1).

The Register noted, and this was amplified in the current survey, similar or other congenital anomalies in the patients and their first, second, and third

degree relatives. The pregnancy history included gestation length, birth weight, and presence of hydramnios, oligohydramnios, fetal malposition, or other complications. The mothers' previous menstrual and obstetric history had been obtained, as well as details of chronic illness and drugs taken during the relevant pregnancy. Epidemiological data had been noted relating to parental age, parity, social class, season of birth, and legitimacy of the child. Finally, the general response to treatment of these deformities was noted at the time of the current survey.

Results

POPULATION FREQUENCY

The total frequency for these deformities was 6.39 per 1000 live births (talipes equinovarus 0.64, talipes calcaneovalgus 0.43, metatarsus varus 0.20, neonatal congenital dislocation of the hip 4.61, and infantile idiopathic scoliosis up to 3 years of age 0.51).

SEX RATIOS (TABLE 2)

These were approximately as noted in many other surveys, with the exception that talipes equinovarus was nearly four times more common in males than the usually quoted twice, and congenital dislocation of the hip only twice as common in females, whereas four or five times is more usually quoted. Infantile idiopathic scoliosis was commoner in males, in the ratio of about 2:1.

TABLE 1 *Eight patients with more than one deformity*

	<i>Talipes equinovarus</i>	<i>Talipes calcaneovalgus</i>	<i>Metatarsus varus</i>	<i>Congenital dislocation of the hip</i>	<i>Infantile idiopathic scoliosis</i>
1		+		+	+
2				+	+
3				+	+
4		+		+	
5		+			+
6	+				+
7	+			+	
8		+	+		

TABLE 2 *Number of cases and sex ratio*

<i>Deformity</i>	<i>Males</i>	<i>Females</i>	<i>Total</i>	<i>Sex ratio</i>
Talipes equinovarus	26	7	33	3.71
Talipes calcaneovalgus	9	13	22	0.69
Metatarsus varus	4	6	10	0.67
Congenital dislocation of the hip	27	56	83	0.48
Infantile idiopathic scoliosis (to 3 years of age)	18	8	26	2.25
Total	84	90	174*	0.93

*165 subjects as 8 patients had more than one defect. See table 1.

FREQUENCY OF HYDRAMNIOS, OLIGOHYDRAMNIOS, AND FETAL MALPOSITION

All these complications of pregnancy tend to be more frequent in association with congenital anomalies (table 3). The neural tube defects of anencephaly, spina bifida, and meningocele and similar abnormalities are noted separately because of their high frequency. The expected proportion of pregnancies reported with hydramnios with a normal baby was 2.5%, with oligohydramnios 0.3%, and with malposition 4.0%. There were no significant findings in relation to hydramnios and oligohydramnios in the patients in this survey although figures were slightly in excess of normal. A significant excess of malpresentation, usually breech, occurred only in congenital dislocation of the hip and infantile idiopathic scoliosis.

SIDE OF DEFORMITY (TABLE 4)

The minor deformities of talipes calcaneovalgus and metatarsus varus are too few in number for comment, but it is clear that talipes equinovarus has no preferential side, being equally left or right sided or

TABLE 3 *Frequency of hydramnios, oligohydramnios, and malposition in pregnancies with normal and abnormal infants*

<i>Deformity</i>	<i>Hydramnios</i>	<i>Oligo-hydramnios</i>	<i>Malposition</i>
Talipes equinovarus† (n=33)	2 (6.1%)	0	1 (3.0%)
Talipes calcaneovalgus† (n=22)	0	0	2 (9.1%)
Metatarsus varus† (n=10)	1	0	1
Congenital dislocation of the hip† (n=83)	4 (4.8%)	0	16 (19.3%)
Infantile idiopathic scoliosis* (n=24)	0	0	7 (29.2%)
Neural tube defects† (spina bifida, anencephaly) (n=137)	107 (78.1%)	0	57 (41.6%)
All other congenital defects† (n=1249)	69 (5.5%)	13 (1.0%)	94 (7.5%)
Normal infant† (n=692)	17 (2.5%)	2 (0.3%)	28 (4.0%)

*Edinburgh Scoliosis Clinic, retrospective history only.

†Edinburgh Register of the Newborn 1964-1968.

TABLE 4 *Side of deformity*

<i>Deformity</i>	<i>Left</i>	<i>Right</i>	<i>Bilateral</i>	<i>Total</i>
Talipes equinovarus	9	10	14	33
Talipes calcaneovalgus	4	7	11	22
Metatarsus varus	2	1	7	10
Congenital dislocation of the hip	46	8	29	83
Infantile idiopathic scoliosis	22	3	1 (double primary curve)	26

bilateral. Congenital dislocation of the hip and infantile idiopathic scoliosis were nearly always left sided and an attempt was made to correlate this with the lie in utero (right or left occipitoanterior), but no significant association could be found.

ASSOCIATED DEVELOPMENTAL ANOMALIES

Similar deformities among index patients are noted in table 1 and other anomalies are shown in table 5. By the age of 7 to 11 years approximately 9% of index patients had some additional developmental defect. This is likely to be higher than would be found on a random survey, although precise figures for comparison are not available.

RESPONSE TO TREATMENT

No patient with talipes calcaneovalgus, metatarsus varus, or neonatal congenital dislocation of the hip presented particular problems of treatment at the time of this survey, all correcting easily within a few months to one year. All those with talipes equinovarus needed several years of splinting, sometimes with operative correction also. Twenty-three patients with infantile idiopathic scoliosis had resolving curves requiring no treatment and the remaining three progressed and required bracing.

TABLE 5 *Associated anomalies in index patients 7 to 11 years after birth*

Deformity	Associated defect
Talipes equinovarus (n=33)	1 cleft lip, 1 umbilical hernia
Talipes calcaneovalgus (n=22)	1 brachydactyly, 1 haemangioma of forearm
Metatarsus varus (n=10)	1 mental retardation, 1 inguinal hernia
Congenital dislocation of the hip (n=83)	4 umbilical herniae, 1 pyloric stenosis
Infantile idiopathic scoliosis (n=26)	1 persistent ductus arteriosus, 1 cleft lip/palate, 1 cleft uvula, 1 thumb hypoplasia, 1 inguinal hernia

Genetics

The proportions of affected first degree relatives are shown in table 6. Since it is clear that two or even three of these deformities can occur not only in the same person, but also in their families, the total for the whole group is of interest, the proportions of affected sibs being the most reliable. (Ascertainment of neonatal dislocation of the hip, talipes calcaneovalgus, metatarsus varus, or resolving infantile scoliosis in the parents' own early infancy will necessarily be incomplete.) Eleven of 189 sibs (5.8%) had exactly the same deformity as the index patient, rising to 16 of 189 (8.5%) when all types of deformity are included. The overall population incidence for these deformities was 6.4 per 1000 live births or 0.64%. Thus the increased number of deformities in the near family is some 13 times greater than expected for the general population.

The proportions of second and third degree relatives affected are shown in table 7, omitting infantile idiopathic scoliosis since no attempt was made to seek out and examine these more distant

TABLE 7 *Proportions of second and third degree relatives with similar deformities*

Index patient deformity	2nd degree relatives (excluding grandparents)	3rd degree relatives (1st cousins only)
Talipes equinovarus (n=33)	2/204	3/230
Talipes calcaneovalgus (n=22)	0/89	0/44
Metatarsus varus (n=10)	1/45	1/47
Congenital dislocation of the hip (n=83)	2/480	1/433
Infantile idiopathic scoliosis (n=26)	(Not examined)	(Not examined)
Total	5/818 (0.6%)	5/754 (0.7%)

TABLE 6 *Proportions of first degree relatives with similar deformities*

Index patient deformity	Same deformity as index patient			Different deformity from index patient*		Grand total
	Parents	Sibs	Total			
Talipes equinovarus (n=33)	0/66	3/41	3/107	1 mother 1 sister	CV CDH	5/107
Talipes calcaneovalgus (n=22)	0/44	0/10	0/54	1 brother 1 brother	CDH TEV	2/54
Metatarsus varus (n=10)	1/20	0/9	1/29	1 brother	CDH	2/29
Congenital dislocation of the hip (n=83)	0/166	8/90	8/256	1 father	TEV	9/256
Infantile idiopathic scoliosis (n=26)	4/52	0/39	4/91	1 brother	CDH	5/91
Total	5/348 (1.4%)	11/189 (5.8%)	16/537 (3.0%)		4 CDH 2 TEV 1 CV	23/537 (4.3%)

*CV = Talipes calcaneovalgus.

CDH = Congenital dislocation of the hip.

TEV = Talipes equinovarus.

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relatives. The proportions drop nearer the population incidence but are still above the expected figure. Ascertainment is likely to be more complete for the third degree than the second degree relatives (first cousins usually being contemporary with the index patients), hence the slightly higher proportion affected among them.

There were no instances of consanguinity among the parents of patients but there was one among the 692 controls (1.4 per 1000). Associated developmental anomalies among the relatives of index patients were unremarkable with the exception of inguinal herniae among the first degree relatives of patients with congenital dislocation of the hip (five of 256, approximately 2%). There was only one sib with spina bifida, giving some confirmation that patients with these structural deformities had been correctly assigned to an 'idiopathic' group and those associated with neural tube defects removed from the survey.

Antenatal development**TWINS**

It has long been suggested that a twin pregnancy could be a contributory factor in causing deformity in the fetus through intrauterine compression from overcrowding. Table 8 shows that the frequency of twin pregnancies was indeed higher than expected from the 692 controls. Seven of the 165 pregnancies (4.2% or approximately one in 25) had a twin whereas the figure in the control group was only eight of 692 (1.2% or approximately one in 87). In only one of the seven twin pairs did both infants have a deformity (congenital dislocation of the hip). The excess of twins was most obvious among the metatarsus varus and infantile scoliosis patients, though only reaching statistical significance in the former. There were no instances of monozygotic twins among the patients.

GESTATION LENGTH AND BIRTH WEIGHT

In all cases birth weights were normal for gestation

TABLE 8 *Twin pregnancies*

<i>Index patient deformity</i>	<i>No of twin pregnancies</i>	<i>Mono/dizygotic</i>	<i>Concordant/discordant</i>
Talipes equinovarus (n=33)	2	Dizygotic (1 like, 1 unlike sex)	Discordant
Talipes calcaneovalgus (n=22)	0	—	—
Metatarsus varus (n=10)	2	Dizygotic (unlike sex)	Discordant
Congenital dislocation of the hip (n=83)	1	Dizygotic (unlike sex)	Concordant
Infantile idiopathic scoliosis (n=26)	2	Dizygotic (1 like, 1 unlike sex)	Discordant
Normal infants (n=692)	8	4 monozygotic 3 dizygotic 1 not known	—

length when compared with the control group. Gestation length was significantly less than normal only among patients with infantile idiopathic scoliosis: five of the 24 cases where data were available (20.8%) were premature (37 weeks or less), compared with only 6.6% of the controls.

Social factors**SOCIAL CLASS**

No social class effect was found when compared with the controls.

ILLEGITIMACY

There were no significant findings in comparison with the controls, 6.8% of patients and 8.4% of normal children being illegitimate or born within three months of marriage.

SEASON OF BIRTH

Four complete years were taken (table 9), the expected ratio of winter to summer births from the control group being 1.15. Neonatal congenital dislocation of the hip was the only condition in which there was an excess of births in the two winter quarters of the year (1.8:1), as described in many other surveys, though with the small numbers investigated here the figures did not reach statistical significance. The numbers of winter and summer births of patients with infantile idiopathic scoliosis were equal, but there was a significant excess of curves developing during the winter months. Nineteen of the 24 curves (79%) with a known time of onset developed in the winter and only five in the summer.

PARENTAL AGE

No significant paternal or maternal age effect was noted among the parents of children with foot deformities, and their position in the family was similar to the control group. There were positive findings among patients with neonatal congenital

TABLE 9 *Season of birth of index patients (4 complete years)*

<i>Index patient deformity</i>	<i>Winter (Oct-Mar)</i>	<i>Summer (April-Sept)</i>	<i>Ratio</i>
Talipes equinovarus (n=27)	17	10	1.7
Talipes calcaneovalgus (n=20)	9	11	0.8
Metatarsus varus (n=5)	4	1	(Too few)
Congenital dislocation of the hip (n=72)	46	26	1.8
Infantile idiopathic scoliosis (n=24)	12	12	1
(Onset of curve)	(19)	(5)	(3.8)
Controls	300	260	1.15

dislocation of the hip (table 10) in which the well known excess of first born children was confirmed, though surprisingly only found to be a feature where the mother was 25 years and older. The mean paternal age in the congenital dislocation of the hip group was significantly higher than average (30.44 ± 0.75 years compared with 28.84 ± 0.25 years in the control group). The parental age difference was not significantly different from normal.

Maternal history

PREVIOUS ABORTIONS AND STILLBIRTHS

The proportions were not significantly different when compared with the control group.

MENSTRUAL HISTORY

The Edinburgh Register noted age at first menstruation, irregularity of the menstrual cycle, and 'severe incapacitating dysmenorrhoea'. It is not possible to assess these points very accurately, and there were no unusual findings among mothers of patients with foot deformities or infantile scoliosis. However, among mothers of children with congenital dislocation of the hip there were fewer with cycle irregularity (11.4% compared with 24.7% of mothers with normal babies), and even fewer who had ever had severe incapacitating dysmenorrhoea (3.8% compared with 22.4% of the controls).

MATERNAL ILLNESS DURING PREGNANCY

In seven of the 33 patients with talipes equinovarus (21.2%), the mother had had an antepartum haemorrhage (four in the first trimester and three later). This was in excess of the controls (8.7%). In eight cases of talipes equinovarus (24.2%) the mother had high blood pressure during pregnancy (six mild and two requiring hospital admission for several weeks). This is in excess of the 10% noted among the control group. There were no abnormal findings relating to antepartum haemorrhage or toxæmia of pregnancy among mothers of children with the other deformities.

TABLE 10 *Maternal age and parity: 83 index patients with congenital dislocation of the hip*

Maternal age (years)	Parity			Total
	0	1	2+	
15-24	19 (26.03)*	10 (7.67)	3 (3.96)	32 (37.66)
25-29	17 (6.47)	8 (9.00)	7 (9.59)	32 (25.06)
30+	7 (2.28)	5 (4.90)	7 (13.09)	19 (20.27)
Total	43 (34.78)	23 (21.57)	17 (26.64)	83

*'Expected' figure from control survey in parentheses.

$\chi^2_{(1)} = 33.39$, $p < 0.0005$.

TABLE 11 *Maternal upper respiratory infection*

	Summer birth (April-Sept)	Winter birth (Oct-Mar)	Total
Talipes equinovarus (n=33)	0/13	0/20	0/33
Talipes calcaneovalgus (n=22)	0/13	0/9	0/22
Metatarsus varus (n=10)	0/4	0/6	0/10
Congenital dislocation of the hip (n=83)	1/30	11/53* (20.8%)	12/83 (14.5%)
Infantile idiopathic scoliosis (n=24)	0/12	0/12	0/24
Neural tube defect (spina bifida, anencephaly) (n=137)	5/74	1/63	6/137 (4.4%)

* $\chi^2_{(1)} = 17.9$: very highly significant excess ($p < 0.0005$).

There were no significant findings in relation to urinary tract infections in comparison with the control group, in each case about 7% being affected.

There was an unexpected excess of upper respiratory infections (both viral and bacterial) in mothers of patients with neonatal congenital dislocation of the hip. It has already been noted that there was an excess of these patients during the winter months, and table 11 shows a comparison with other deformities, broken down by season of birth. Since figures for maternal illness were also available for the more serious deformities of anencephaly and spina bifida with meningocele, they are included in table 11, but these too fall well below the figures for congenital dislocation of the hip.

MOTHERS' CHRONIC ILLNESS AND DRUGS TAKEN

Disorders such as diabetes mellitus, rheumatoid arthritis, or chronic heart disease in the mother were noted but in no instance was there a significant excess when compared with the control group. There were no obvious findings in relation to drugs taken during pregnancy.

Discussion

The survey confirms many others in suggesting a multifactorial genetic background for these deformities, but it also seems likely that the whole group is aetiologically related. The evidence for this is not only that more than one deformity occurs in the same subject, a long established clinical observation, but also among the first degree relatives of patients. In addition, environmental factors must also be needed to 'trigger off' the deformity, and it is suggested that while the multifactorial genetic background may be similar for the whole group, each has differing environmental factors determining which individual deformity develops.

It was interesting that there was no evidence for an intrauterine pressure disturbance associated with hydramnios or oligohydramnios; indeed no single instance of the latter was reported. It seems that although severe oligohydramnios can cause fetal deformity (as in Potter's syndrome), in the great majority of cases of the uncomplicated idiopathic deformities discussed here there is no clear evidence for this. However, it is possible that a minor or transient disturbance would not be detected clinically, particularly if it occurred in the earlier months of pregnancy.¹⁸ The excess of twin pregnancies is interesting, suggesting that compression from overcrowding could be relevant.

Positive findings relating to the abnormal environment are discussed for each individual deformity. Numbers are small and any further statistical evaluation not really valid, bearing in mind also the difficulty in evaluating some of the clinical data (for example, maternal menstrual histories), though every care has been taken to standardise this as far as possible.

TALIPES EQUINOVARUS

This was the only deformity in which antepartum haemorrhage and maternal toxæmia occurred more frequently than in the control group. Is this associated with the clinical impression from this country and North America that many fewer cases of talipes equinovarus are being seen now than was the case 20 or 30 years ago? Certainly the population frequency noted here (0.64 per 1000) is less than the usually quoted 1 per 1000. The reason for this natural decline is not known, but antenatal care is now of a higher standard: with less severe toxæmia is there less club foot?

There was some evidence that this deformity occurred earlier in fetal life than the others. There was no greater frequency of left or right side involvement and the deformity was nearly always severe, needing long periods of splinting or operative correction. Also, it was the only one of these deformities found to be associated with the severe oligohydramnios of Potter's syndrome, indicating perhaps that early in pregnancy the feet can readily become set in the equinovarus position.

TALIPES CALCANEVALGUS

In the few cases in this survey no environmental factor was noted.

METATARSUS VARUS

There were surprisingly few cases (10) in the survey, and two of these were twin pregnancies, which could possibly indicate that overcrowding is significant. It is common knowledge that the deformity is more frequent in the United States and often develops,

or is noticed, a short time after birth. Perhaps postnatal factors can be significant in that North American infants are more often kept lying prone, which could, postnatally, give rise to this deformity.

NEONATAL CONGENITAL DISLOCATION OF THE HIP

Environmental factors noted in other surveys have been confirmed, namely the excess of left sided deformities, of first born children (though shown here to be significant only in mothers aged 25 years and older), of breech presentations or versions, and of children born in the winter months. Additional factors noted in the current survey were an increased paternal age and a lack of menstrual cycle irregularity and severe dysmenorrhoea in the mother, when compared with mothers of normal babies. Could this be an indication of higher levels of maternal oestrogen than average? It was long ago suggested that oestrogen excess was related to excessive joint laxity in these children, and also to the excess of females with the deformity.^{19 20} These findings were not confirmed by Thieme *et al.*,²¹ but investigation with improved techniques might prove helpful. Familial generalised joint laxity was not specifically reinvestigated for this survey, but is undoubtedly one of the genetic aetiological factors in many cases of congenital dislocation of the hip.^{8 22}

The current survey noted an unexpected excess of mothers who had had an upper respiratory infection during pregnancy, and though it was not possible always to ascertain the exact time of this the majority were after the first trimester. It is usually stated that a mother who has a deformed child is more likely over-enthusiastically to remember a minor episode of infection, but if this were the reason for the excess, it would surely be equally likely in mothers of children with the other deformities, and even more likely in the more serious (and obvious) defects of anencephaly or spina bifida and meningocele. Since no other deformity was associated with this feature, is there some direct cause and effect? Does the fetus perhaps also have an infection and for a short crucial period of time fail to move around and kick as it should? The observation does at least tie in with the well established fact reported from many countries that congenital dislocation of the hip is commoner in the winter months, but that this does not correlate with climatic temperature.¹⁶

INFANTILE IDIOPATHIC SCOLIOSIS

This is clearly an early postnatal deformity, no case being noted in the Register of congenital defects. Findings from a previous survey from this unit were confirmed in that there was an excess of breech

births (one in three) and, like congenital dislocation of the hip, the greater proportion of deformities were left sided. This was the only deformity in which prematurity was a feature. The season of birth was unremarkable but the onset of the curve was during the winter months of the year in over three-quarters of cases. Both these observations suggest that the immobile, over-wrapped up child is particularly vulnerable to the development of this deformity.

Conclusion

It is suggested that the idiopathic deformities of talipes equinovarus and calcaneovalgus, metatarsus varus, neonatal congenital dislocation of the hip, and infantile scoliosis are aetiologically related, since one subject may have more than one of these defects, and each of them may appear within the same family. Inheritance is likely to be multifactorial, with environmental factors which 'trigger' the deformity. Compression in utero because of hydramnios or oligohydramnios could not be shown as a causative factor, but a number of other environmental factors, both prenatal and immediately postnatal, were confirmed or suggested. We conclude that it is a mistake to look for a single isolated cause for any one of these deformities, but all are likely to have a common multifactorial genetic background associated with differing intrauterine or postnatal environmental factors.

References

- 1 Alberman ED. The causes of congenital club foot. *Arch Dis Child* 1965;40:213, 548-54.
- 2 Wynne-Davies R. Family studies and aetiology of club foot. *J Med Genet* 1965;2:227-32.
- 3 Ching GHS, Chung CS, Nemecek RW. Genetic and epidemiological studies of clubfoot in Hawaii: ascertainment and incidence. *Am J Hum Genet* 1969;21:566.
- 4 Chung CS, Nemecek RW, Larsen IJ, Ching GHS. Genetic and epidemiological studies of clubfoot in Hawaii. General and medical considerations. *Hum Hered* 1969;19:321-42.
- 5 Record RG, Edwards JH. Environmental influences related to the aetiology of congenital dislocation of the hip. *Br J Prev Soc Med* 1958;12:8.
- 6 Medalie JH, Makin HM, Alkalay E, Yofe J, Cochari Z, Elvich D. Congenital dislocation of the hip. A clinico-epidemiological study, Jerusalem 1954-1960. Retrospective incidence study. *Isr J Med Sci* 1966;2:212.
- 7 Woolf CM, Koehn JH, Coleman SS. Congenital hip disease in Utah: the influence of genetic and nongenetic factors. *Am J Hum Genet* 1968;20:430-9.
- 8 Wynne-Davies R. Acetabular dysplasia and familial joint laxity: two aetiological factors in congenital dislocation of the hip. *J Bone Joint Surg [Br]* 1970;52:704-16.
- 9 Czeizel A, Szentpetery J, Tusnady G, Vizelety T. Two family studies on congenital dislocation of the hip after early orthopaedic screening in Hungary. *J Med Genet* 1975;12:125-34.
- 10 Riseborough EJ, Wynne-Davies R. A genetic survey of idiopathic scoliosis in Boston, Massachusetts. *J Bone Joint Surg [Am]* 1973;55:974.
- 11 Wynne-Davies R. Infantile idiopathic scoliosis. Causative factors, particularly in the first six months of life. *J Bone Joint Surg [Br]* 1975;57:138-41.
- 12 Browne D. Congenital deformities of mechanical origin. *Arch Dis Child* 1955;30:37-41.
- 13 Dunn PM. Congenital postural deformities. *Br Med Bull* 1976;32:71-6.
- 14 Watson GH. Relation between side of plagiocephaly, dislocation of hip, scoliosis, bat ears, and sternomastoid tumours. *Arch Dis Child* 1971;46:203-10.
- 15 Robinson GW. Birth characteristics of children with congenital dislocation of the hip. *Am J Epidemiol* 1968;87:275.
- 16 Chen R, Weissman SL, Salama R, Klingberg MA. Congenital dislocation of the hip (CDH) and seasonality: the gestational age of vulnerability to some seasonal factor. *Am J Epidemiol* 1970;92:287-93.
- 17 Wynne-Davies R. A family study of neonatal and late-diagnosis congenital dislocation of the hip. *J Med Genet* 1970;7:315-33.
- 18 Medical Research Council Report. An assessment of the hazards of amniocentesis. *Br J Obstet Gynaecol* 1978;85: suppl 2.
- 19 Andrén L, Borglin NE. Disturbed urinary excretion pattern of oestrogens in newborns with congenital dislocation of the hip. *Acta Endocrinol* 1961;37:423, 427.
- 20 Aarskog D, Støa KF, Thorsen T. Urinary oestrogen excretion in newborn infants with congenital dislocation of the hip joint. *Acta Paediatr Scand* 1966;55:394.
- 21 Thieme WT, Wynne-Davies R, Blair HAF, Bell ET, Loraine JA. Clinical examination and urinary oestrogen assays in newborn children with congenital dislocation of the hip. *J Bone Joint Surg [Br]* 1968;50:546-50.
- 22 Carter C, Wilkinson J. Persistent joint laxity and congenital dislocation of the hip. *J Bone Joint Surg [Br]* 1964;46:40-5.

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